energy threshold, to leave the second conductor layer substantially unvaporized and thereby form a depthwise self-limiting blind via.--

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REMARKS

Claims 1, 2, 4-18, 20-22, 24, 26, 29, and 31-34 are in the application. Claims 1, 31, and 34 are in independent form. Claims 1, 4, 22, and 24 are amended. Claims 23, 25, 27, 28, and 30 are cancelled. Claims 31-34 are added.

The Examiner has withdrawn claim 30 for being directed to a nonelected invention. Applicants cancel claim 30 without traverse.

Claims 1, 2, 4-15, and 20-29 stand rejected under 35 USC 103(a) for obviousness over U.S. Patent 5,593,606 to Owen et al. (Owen '606) in view of U.S. Patent 4,644,130 to Bachmann.

> "It is first noted that Owen '606 qualifies as prior art under 35 USC 102(e) for the following reasons. It is the work of 'another' as the inventive entity of Owen '606, namely applying the second laser output to the target to remove the dielectric layer within the second spot area. The first and second laser outputs have different peak powers.
>
> "Owen '606 does not specifically state that the second energy density is less than the first and second conductor ablation energy thresholds.
>
> "Referring to col. 3, lines 1-5, Bachmann shows that it is known in the art to produce a depthwise self-limiting blind via by applying a laser output to a dielectric layer located above a metal layer such that the energy density of the laser output is greater than the dielectric ablation threshold, but less than the conductor ablation energy threshold. The vias thus produced are said to have a high reliability, as material erosion stops at the conductor layer. It would have been obvious to one of ordinary skill in the art at the time the invention was made to use a second energy density in Owen '606 of less than the first and second conductor ablation energy thresholds, to ensure that material erosion stops at the lower conductor layer and thereby produce a blind via of high reliability as taught by Bachmann.

"Regarding claims 2, 9-13, 20-24, 26, and 27, the features recited therein are clearly shown by Owen '606.

"Regarding claims 4, 25, and 28, although Owen does not state how the different powers are achieved, it is well known in the art that the output of a Q-switched laser is inversely proportional to its repetition rate, as lower rep rates allow more energy to be stored in the laser prior to emitting a pulse. Accordingly, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use a higher repetition rate when processing the dielectric material to easily achieve the required lower power, in a conventional manner.

"Regarding claims 5 and 6, Owen '606 suggests using different powers for the different layers, and a person of ordinary skill in the art, given Bachmann, would have interpreted this as fairly suggesting the use of a higher power for the metal layers than for the dielectric layer, as it was a well-known fact in that art that the ablation threshold for metal is higher than that of the dielectrics of interest.

"Regarding claims 7, 8, 14, 15, and 29, although Owen '606 shows changing the energy incident on the target area (i.e., the energy density) by changing the power output of the laser, it would have been equally obvious to one of ordinary skill in the art at the time the invention was made to change the energy density by changing the spot size of the laser upon the target area since the examiner takes Official Notice of the equivalence of the step of changing a laser's output power and the step of changing a spot size for their use in the laser machining art and the selection of any of these known equivalents to change the energy density provided on a target surface would be within the level of ordinary skill in the art. In re Fout, 213 USPQ 532 (CCPA 1982). This equivalence may be shown by the equation: $E_d = (P/A) * t$, where E_d is the energy density, P is the beam power, A is the area of the beam spot on the workpiece, and t is the pulse length. The energy density may clearly be set to a desired value by changing either the power or the spot size.

"It would have been obvious to one of ordinary skill in the art at the time the invention was made to change the spot size either through using a variable focus lens or by moving the workpiece, both methods being notoriously old and well-known in the art for the purpose of adjusting a

laser spot size on a workpiece, to conveniently achieve a required change in size.

> "Regarding claim 18, Bachmann (col. 3, lines 5-7 and 20) also shows that it is known in the art to laser drill non-circular vias. It would have been obvious to one of ordinary skill in the art at the time the invention was made to use the process of Owen '606 to form a non-circular via to produce a desired circuit board configuration as illustrated by Bachmann."

Applicants respond to this rejection as follows.

Applicants have amended claim 1 to include subject matter from previous claims 4, 23, 25, 27, and 28 to specify that the pulses are generated at first and second repetition rates from the same nonexcimer laser and that the second repetition rate is greater than the first repetition rate to decrease the energy density.

Bachmann forms multiple holes in a top metal layer with a photoetch process not described. The remaining top metal layer then acts as a mask against a large area, low energy density (750 mW/cm^2), UV beam spot from a KrF excimer laser that drills simultaneously multiple vias through the underlying dielectric layer. Since the drilling pulses are not used to make the holes in the top metal layer, there is no change required for the drilling to stop at the bottom metal layer. There is no suggestion in Bachmann to drill both the top metal and dielectric layers of his targets with the same laser or to reduce the energy density of the laser output to avoid drilling the bottom metal layer.

The Examiner concedes that Owen '606 does not state how the different peak powers are achieved for processing different layers or that the second energy density is less than the first energy density. Applicants also note that Owen '606 mentions nothing about changing the repetition rate in connection with processing different layers.

The Examiner presents a known inverse relationship between laser output power and repetition rate. There is no showing of or suggestion for changing the repetition rate of either an excimer or a CO_2 laser between steps of drilling a single via.

The repetition rate is typically predetermined for a given operation and is not changed during the middle of a process. This is especially true for excimer and CO_2 lasers. With respect to solid-state lasers, increasing the repetition rate of conventional infrared solid-state lasers at high repetition rates does not significantly affect the average power of the output. A copy, included for the Examiner's convenience, of the graph in Figs. 3-38, from the ESI *Model 4570 Series Lasers Service Guide*, shows that the average power curve is almost flat for conventional IR solid-state lasers at repetition rates above 6 kHz. Thus, one skilled in the art would not readily look to increase the repetition rate to decrease the output power of a solid-state laser at high repetition rates. ESI's solid-state UV laser exhibits, however, a significant drop in average power for moderate increase in repetition rate above about 2 kHz. This phenomenon is demonstrated in Fig. 3-39, *ibid.* Changing the repetition rate was not obvious to try, and the success of the results were unexpected.

The Examiner also remarks on the known relationship between spot size and power density. In commercial nonexcimer laser applications, spot size is typically set in relation to the size of the target, such that the spot size is as small as feasible and often determines the size of the target. These lasers generally do not use projection masks to determine the size of the target, so increasing the spot size would increase the spot area on the target. Thus in these prior art systems, the energy density is attenuated as needed by pulse shaping or attenuators. The spot size is not changed to adjust the power density.

Excimer and CO_2 lasers, which generate a spot size that is significantly larger than a desirable spot area on a target, would generally require a projection mask and or complex optics to achieve a desirable spot area. Due to the presence of a projection mask and/or the complexity of the optics, one skilled in the art would be disinclined to change the spot size in order to change the power density. Typically for an excimer, the current and the mask profile and would be changed to alter the power density and the spot area.

Applicants note that in U.S. Patent No. 5,073,687, Inagawa et al. (PTO Form 1449, June 17, 1996, reference AH) employ an excimer laser and vary the focal point of each pulse to maintain the focus of the existing bottom of the hole being drilled to keep the hole taper constant (not to change the power density). Changes to the peak power and pulse duration adjust the power density to avoid thermal damage to the dielectric layer. There is no attempt to stop at the bottom metal layer; in contradistinction, Inagawa et al. increase the power density to drill through the bottom metal layer.

In view of the above, applicants request that the rejection of claims 1, 2, 4-15, and 20-22, 24, 26, and 29 be withdrawn.

Claims 16 and 17 stand rejected under 35 USC 103(a) for obviousness over U.S. Patent 5,593,606 to Owen et al. (Owen '606) in view of U.S. Patent 4,644,130 to Bachmann as applied to claims 1, 2, 4-15, and 20-29 above, and further in view of U.S. Patent 5,227,013 to Kumar.

> "As applied above, Owen '606 in view of Bachmann discloses the invention substantially as claimed, but does not show repeating the disclosed process to produce a stepped via as claimed.
>
> "Referring to Fig. 6, Kumar shows that it is known in the art to laser drill stepped vias in printed circuit boards. It would have been obvious to one of ordinary skill in the art at the time the invention was made to merely repeat the steps of Owen '606 and form a stepped via to produce a desired circuit board configuration as illustrated by Kumar."

Applicants respond to this rejection as follows.

Claims 16 and 17 depend, respectively, directly or indirectly from claim 1, which applicants believe to be allowable. Applicants submit, therefore, that dependent claims 16 and 17 are allowable and request that the rejection be withdrawn.

Applicants have added independent Claim 31. Claim 31 recites first and second energy densities and includes nearly all of the limitations of claim 1 of the parent U.S. Patent No. 5,593,606. Applicants believe that

claim 31 is fully supported by the specification of the subject application and the specification of the '606 patent (which was incorporated by reference) and particularly by its Example 8 in column 11. Claim 31 is, therefore, entitled to the filing date of the '606 patent, and the '606 patent does not qualify as 102(e) prior art against claim 31. Applicants will submit, if required, a terminal disclaimer to overcome an obviousness-type double patenting rejection of claim 31 over the '606 patent. Claim 32 depends on claim 31 and recites many of the elements of amended claim 1 with respect to changing the repetition rate and is believed to be allowable. Claim 33 also depends on claim 31 and recites changing the distance between the focal plane and target to change the spot size and decrease the energy density over the spatial spot size. This claim is also believed to be allowable. Added independent claim 34 recites many of the elements of claim 32 and is believed to be allowable for reasons previously discussed.

Applicants believe that their application is in condition for allowance and respectfully request the same.

Respectfully submitted,

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